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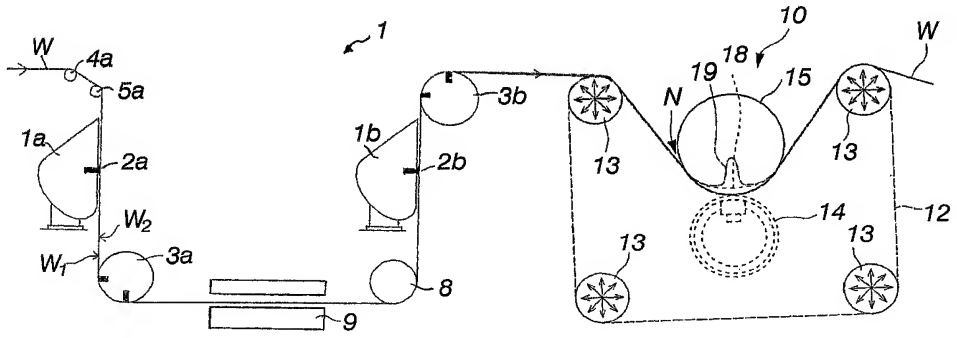
(54) **Title:** METHOD AND APPARATUS FOR THE SURFACE TREATMENT OF PAPER/BOARD



(57) **Abstract:** The invention relates to a method and apparatus for the surface treatment of paper/board. The method comprises treating a fibrous web with a drying- shrinkage achieving chemical, such that the chemical penetrates substantially throughout the fibrous web thickness, and thereafter the fibrous web is set to proceed to a treatment zone (N) between two heated metal surfaces (12, 15) with a result that moisture within the fibrous web migrates into a middle portion, whereby the middle portion swells as a result of increased moisture and the surface portion is subjected to a high drying stress as the surface portion is prevented from shrinking. As the fibrous web exits from the treatment zone, the vaporized water escapes rapidly through surface pores without substantial condensation in the surface layers, resulting in an increased elastic modulus for the surfaces and at the same time a low density for the middle portion.

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Method and apparatus for the surface treatment of paper/board

The present invention relates to a method and apparatus for the surface treatment of paper/board.

In printing paper grades and board, a high flexural strength is desirable for adequate runnability and printability. Flexural strength can be increased e.g. by surface sizing, as well as by various gradient structures (multiple structures as well as gradient calendering). A high bulk is desirable for achieving a constant thickness with a smaller amount of pulp.

An objective of surface sizing is to improve the strength properties of paper or board, such as internal bond strength (interlaminar strength) or surface strength (picking). Chemicals for use in surface sizing are water-soluble polymers, comprising predominantly starches because of the attractive price thereof. The raw material for starches includes plants, such as corn, wheat, barley, potato, tapioca, etc., the tubers, seeds, etc. thereof being sources of starch. Starch ($C_6H_{10}O_5$) consists of straight-chain amylose and branched amylopectin. Other chemicals for use in surface sizing are e.g. various cellulose derivatives (CMC), as well as polyvinyl alcohol (PVA).

Flexural strength is reduced in calendering as the web compresses, resulting in a lower thickness and reduced bulk. Calculated flexural strength increases in proportion to the third power of thickness according to the following formulae:

$$\frac{S_1}{S_2} = \frac{E_1 h_1^3}{E_2 h_2^3}$$

$$\frac{E_1}{E_2} = \frac{h_2}{h_1}$$

$$\frac{h_2 h_1^3}{h_1 h_2^3} = \frac{h_1^2}{h_2^2}$$

wherein

S_1 and S_2 represent flexural strengths of calendered and uncalendered paper, respectively, and

h_1 and h_2 represent thicknesses of calendered and uncalendered paper, respectively, and

E_1 and E_2 represent elastic moduli of calendered and uncalendered paper, respectively.

The following general description deals with paper and board grades, as well as various calendering and coating processes for use in the manufacture thereof.

Paper and board grades

A wide range of various grades of paper and board are in existence and can be divided on the basis of basis weight in two categories: papers with a single ply and a basis weight of 25-300 g/m² and boards possibly made in multiply technique with a basis weight of 150-600 g/m². As noted, the dividing line between paper and board is fluctuating, the boards of lowest basis weight being lighter than the heaviest papers. Ordinarily, paper is used for printing and board for packaging.

The following descriptions are examples of presently employed values for fibrous webs and substantial deviations from the given values may occur. The principal source publication for the descriptions is Papermaking Science and Technology, Papermaking Part 3, Finishing, edited by Jokio, M., published by Fapet Oy, Jyväskylä 1999, 361 pages, and Papermaking Science and Technology, Paper and Board grades, edited by Paulapuro, H., published by Fapet Oy, Jyväskylä 2000, 134 pages.

Printing papers made of mechanical pulp, i.e. those with a wood content, include newsprint, uncoated magazine and coated magazine paper.

Newsprint consists either completely of mechanical pulp or may contain some bleached softwood pulp (0-15%), and/or some of the mechanical pulp can be replaced by recycled fiber pulp. General values for newsprint can probably be considered as follows: basis weight 40-48.8 g/m², ash content (SCAN-P 5:63) 0-20%, PPS s10 roughness (SCAN-P 76-95) 3.0-4.5 µm, Bendtsen roughness (SCAN-

P21:67) 100-200 ml/min, density 600-750 kg/m^3, brightness (ISO 2470:1999) 57-63%, and opacity (ISO 2470:1998) 90-96%.

Uncoated magazine paper (SC = supercalendered) comprises generally 50-70% of mechanical pulp, 10-25% of bleached softwood pulp, and 15-30% of fillers. Typical values for calendered SC paper (including e.g. SC-C, SC-B, and SC-A/A+) are basis weight of 40-60 g/m^2, ash content (SCAN-P 5:63) of 0-35%, Hunter gloss (ISO/DIS 8254/1) of <20-50%, PPS s10 roughness (SCAN-P 76:95) of 1.0-2.5 µm, density of 700-1250 kg/m^3, brightness (ISO 2470:1999) of 62-70%, and opacity (ISO 2470:1998) of 90-95%.

Table 1 shows typical values for coatable papers which contain mechanical pulp. (MFC = machine finished coated, FCO = film coated offset, LWC = light weight coated, MWC = medium weight coated, HWC = heavy weight coated)

Table 1

	MFC	FCO	LWC	MWC	HWC
basis weight, (g/m^2)	50-70	40-70	40-70	70-90	100 – 135
Hunter gloss (ISO/DIS 8254/1), (%)	25-40	45-55	50-65	65-70	
PPS-s10 roughness, (µm) (SCAN-P 76/95)	2.2-2.8	1.5-2.0	0.8-1.5 (offset) 0.6-1.0 (roto)	0.6-1.0	
density, (kg/m^3)	900-950	1000-1050	1100-1250	1150-1250	
brightness (ISO 2470:1999), (%)	70- 75	70- 75	70- 75	70- 75	
opacity (ISO 2470:1998), (%)	91-95	91-95	89-94	89-94	

Coated magazine paper (LWC = light weight coated) contains 40-60% of mechanical pulp, 25-40% of bleached softwood pulp, and 20-35% of fillers and coatings. HWC (heavy weight coated) can be coated even more than twice.

Woodfree printing papers made of chemical pulp, i.e. fine grade papers, include uncoated - and coated printing papers based on chemical pulp, wherein the proportion of mechanical pulp is less than 10%.

Uncoated printing papers based on chemical pulp (WFU) have 55-80% of bleached birchwood pulp, 0-30% of bleached softwood pulp, and 10-30% of fillers. In WFU, the values fluctuate a great deal: basis weight 50-90 g/m² (up to 240 g/m²), Bendtsen roughness 250-400 ml/min, brightness 86-92%, and opacity 83-98%.

In coated printing papers based on chemical pulp (WFC), the amounts of coating fluctuate a great deal according to requirements and intended application. The following are typical values for once- and twice-coated printing paper based on chemical pulp: once-coated, basis weight 90 g/m², Hunter gloss 65-80%, PPS s10 roughness 0.75-2.2 µm, brightness 80-88%, and opacity 91-94%, and for twice-coated, basis weight 130 g/m², Hunter gloss 70-80%, PPS s10 roughness 0.65-0.95 µm, brightness 83-90%, and opacity 95-97%.

Release papers have a basis weight which varies within the range of 25-150 g/m²

Board making involves the use of chemical pulp, mechanical pulp and/or recycled pulp. Boards can be divided e.g. for the following main categories according to intended application.

Corrugated board provided with a liner and a fluting.

Boxboards for making containers, boxes. Boxboards include e.g. liquid packaging boards (FBB = folding boxboard, LPB = liquid packaging board, WLC = white-lined chipboard, SBS = solid bleached sulfite, SUS = solid unbleached sulfite).

Graphic boards for making e.g. cards, files, folders, casings, covers, etc.

Wallpaper bases.

Calendering

The surface properties and thickness profile of various papers and boards are processed by calendering to meet the requirements of a printing method and further processing. Coated grades are typically precalendered before a coating process and subjected to final calendering after the coating process.

Calenders are grouped in machine calenders, soft calenders, and multi-roll calenders. A machine calender has typically 1-2 nips and both nip-forming rolls are hard rolls. A soft calender has generally 1-4 nips and at least one of the nip-forming rolls is covered with a soft cover. A multi-roll calender has generally 5-11 nips. The roll assembly of a multi-roll calender includes both heated rolls and soft cover rolls.

Special calenders include e.g. a wet stack calender, a breaker stack, and long-nip calenders.

Wet stack calender is more or less identical to a multi-roll machine calender, yet totally different in terms of calendering process. Wet stack calender makes effective use of a moisture gradient, the web arriving at the calender only having a moisture of about 1-2%. Wet stack calender is provided with water boxes for forming a water film on the web surface upstream of a nip, said film being pressed to the web surface in the nip. Thus, the web only becomes wet at the surface, whereby the surface receives more calendering than the overdried interior. Wet stack calender is employed as a precalender for several board grades.

Breaker stack is a machine calender located in the drying section of a paper machine.

Long-nip calenders include a shoe calender, which has a soft belt around a shoe roll and in which the nip length is typically 50-400 mm, as well as belt calenders. The traditional belt calender consists of a soft calender's thermal roll, a belt loop, and a backing roll inside the belt loop, the latter being either a hard roll or a soft roll. The belt runs over a backing roll and guide/tension rolls. A special embodiment of the belt calender is a metal belt calender, wherein the calendering belt comprises a metal belt which travels around guide rolls and establishes, together with a counter-element, typically a roll, a long nip zone having a length of even more than

5000 mm. Inside the belt loop can be further provided a press element, e.g. a deflection-compensated roll, which can be used for establishing a nip point of higher compression load midway across the long nip zone.

Coating techniques

With coated paper grades and coating as a method becoming more and more popular, the coating processes and equipment are challenged by increasing demands. In coating procedure, more specifically in pigment coating procedure, the surface of paper is formed with a layer of coating color at a coating head, followed by performing the draining of water brought in by the coating color composition. The forming of a coating color layer can be divided in supplying a coating color onto the surface of paper, i.e. application, as well as in adjusting the final amount of coating. The most important pigment coating method is so-called blade coating, in which the amount of coating is adjusted by means of a so-called doctor blade. The most common types of blade coating heads include a blade coater provided with an applicator roll and a blade coater provided with jet application. The coating process additionally involves the use of a so-called film transfer coater, the use of which has recently become more and more common. Another new technique being introduced for high-speed printing paper machines involves the use of curtain coaters.

From a practical standpoint, the most essential difference between various coating devices relates to the application process and especially to the penetration occurring therein, i.e. to the penetration of a coating color into the paper.

In the manufacture of high-grade coated printing papers, more and more attention has been lately paid not only to high quality but also to productivity. Quality has likewise become a more important aspect in light coated papers of a bulk product type. Nearly all coaters are under pressure of raising quality, productivity, and running speed.

In applicator-roll application included in blade coating, the application is effected by using a roll rotating in a coating pan for picking up coating color onto the bottom surface of paper carried by a backing roll. The applied amount is normally 200-250 g/m^2. In applicator-roll application, the coating color penetrates effectively into

base paper. In addition, the fibers of base paper have time to swell prior to doctoring, thus increasing the paper's roughness volume.

In jet application, the coating color is in turn supplied directly onto the web surface by means of a nozzle. An advantage over the applicator-roll application is the absence of a rotating roll and hence improved aptitude to high running speeds. Another advantage is a less powerful pulse of application pressure, resulting in improved runnability. In jet application, the web wetting process is an intermediate between a applicator roll and a short dwell. In jet application, the applied amount is typically 130-220 g/m^2.

In short dwell application, the coating color is delivered into an application chamber located immediately behind the doctor blade, one side wall of said chamber being constituted by a moving paper web supported by the backing roll. The moving paper web develops vortices in the application chamber and the coating color has a flowing speed on the paper web's surface which is equal to the paper web's speed. In short dwell application, the wetting of paper is slight as the application zone is subjected to a low pressure and the effective range is short. The swelling of paper fibers occurs partially only downstream of the doctor blade, which roughens the surface smoothed by the blade. Thus, the coating smoothness obtainable by a short dwell coater is inferior to what is achieved by applicator-roll and jet coaters.

The amount of coating remaining on the surface of paper is influenced by a wide range of variables. When such properties of base paper as roughness, porosity, and water absorption, are increasing, the amount of coating will also increase. Likewise, when the dry content and viscosity of a coating color are increasing, the amount of coating will increase. On the other hand, an increase in the water retention capacity of a coating color reduces the amount of coating. When the stress, working angle and blade thickness of a doctor blade are increasing, the amount of coating will in turn be reduced. As for other factors, an increase in running speed as well as an increase in application pressure lead to an increase in the amount of coating.

In addition to the above-described blade coaters, the coating and surface treatment can also be implemented by other devices. The following describes a few most commonly employed options. The size press unit consists of two rotating rolls. In

this alternative, the coating color to be applied onto the surface of a web is applied to the web in a pond present between the web and the rolls. In addition to surface sizing, the size press can also be used for pigment coating. The amount of coating will be about 1,0-2,0 g/m²/side. A problem in the standard size press has been instability of the application pond at high rates of running speed.

Attempts have been made to eliminate the problem by designing film size presses, wherein a layer of coating or sizing agent desired on the surface of a paper web is first applied to the surface of press rolls, the layers passing therefrom to paper in a nip between the rolls. The employed application devices comprise units like short dwell coaters. Advantages gained by the apparatus include a controlled application even at high running speeds and a possibility of pigment coating (2-6 g/m²/side). Furthermore, the coating color can have its dry content increased with respect to a standard size press. The coating of film coating colors can be carried out either in a one- or two-sided manner. The runnability of a film transfer coating process is usually good with respect to blade coating. Compared to blade coating, the coating layer obtained by film transfer coating usually conforms better to the contour and has more coverage in that sense. It is not possible, however, to achieve high amounts of coating (over 10...12 g/m²) by film transfer coating.

In air brush coating, the application of a coating color is performed either by a single- or a multi-roll blade application apparatus or by means of a nozzle. Adjustment of the amount of coating and smoothing of the surface are in turn performed by means of an air jet. Air brush coating is used almost exclusively in board coating because of an excellent coverage provided thereby. Downsides include a limited running speed of the method and quite low dry contents of the coating color. The coating layer formed by an air brush is of a consistent thickness, conforming to the surface contours of paper.

Accordingly, basic solutions today in terms of coating a paper web are provided by short dwell and applicator-roll coaters, equipment based on jet application, and film size presses. An all-purpose general coater is yet to be designed.

Blade coating in its various forms is and seems to remain also in the future the most common coating method. As running speeds increase and areas for applied coating

expand, the applicator roll will probably be replaced almost totally by solutions based on jet application.

One emerging new technique is also a so-called curtain coating technique. Curtain coaters can be divided in slot-fed or slide-fed coaters. In a slide-fed curtain coater, a coating is set flowing along an inclined plane and a curtain develops as the coating trickles over the plane's edge. In slot-fed application beams, a coating is pumped through a distribution chamber to a narrow vertical slot, a curtain developing along its lip and trickling down to the web. A coating can be applied in one or more layers.

Compared to blade coating, curtain coating applies a much lesser force on the web and thus results in fewer disruptions caused by breaks in the paper web, thus improving runnability. Curtain coating is not capable of providing a smoothness equal to that achieved by blade coating, but the coverage obtained thereby is better than what is achieved by blade coating. The principal idea has been that the curtain coater would eventually replace the air brush.

Patent FI 115732 discloses a method and apparatus, whereby the penetration of a surface sizing agent into a fibrous web can be improved by means of a vacuum device.

It is an objective of the present invention to provide a solution capable of further improving the flexural strength and bulk of surface-sized paper/board with respect to values obtained by standard surface sizing and subsequent calendering. In order to accomplish this objective, a method of the invention is characterized in that the method comprises treating a fibrous web with a drying-shrinkage achieving chemical, such that the chemical penetrates substantially throughout the fibrous web thickness, and thereafter the fibrous web is set to proceed to a treatment zone between two heated metal surfaces with a result that moisture within the fibrous web migrates into a middle portion, whereby the middle portion swells as a result of increased moisture and the surface portion is subjected to a high drying stress as the surface portion is prevented from shrinking, and as the fibrous web exits from the treatment zone, the vaporized water escapes rapidly through surface pores without substantial condensation in the surface layers, resulting in an increased

elastic modulus for the surfaces and at the same time a low density for the middle portion.

On the other hand, an apparatus of the invention is characterized in that the apparatus comprises an application unit, by means of which a drying-shrinkage achieving chemical is applicable to a fibrous web, such that the chemical penetrates substantially throughout the fibrous web thickness, and the fibrous web is adapted to proceed through a treatment zone between two heated metal surfaces with a result that moisture within the fibrous web migrates into a middle portion, whereby the middle portion swells as a result of increased moisture and the surface portion is subjected to a high drying stress as the surface portion is prevented from shrinking, whereby, as the fibrous web exits from the treatment zone, the vaporized water escapes rapidly through surface pores without substantial condensation in the surface layers, resulting in an increased elastic modulus for the surfaces and at the same time a low density for the middle portion.

The invention will now be described in more detail with reference to the accompanying drawings, in which:

Fig. 1 shows in a schematic view of principle one exemplary apparatus configuration of the invention, and

Fig. 2 shows apparatus configuration for an enhanced surface treatment.

In reference to fig. 1, the exemplary apparatus comprises a vacuum-operated surface sizing unit as described e.g. in FI Patent 115732, and a metal belt calender 10. The surface-sizing unit 1 includes a first applicator device 1a for applying a starch solution to a first web side W_1 and a first vacuum device 3a, the vacuum existing therein being used for producing a pressure difference across the thickness of a web W and for making the starch solution migrate and penetrate inside the web W to a desired depth. The exemplary apparatus further includes a second applicator device 1b disposed to face a second web side W2, and a second vacuum device 3b disposed to face the first web side W1. This arrangement enables a two-sided surface treatment for the web W, wherein the web W is conveyed downstream of the first vacuum device 3a by way of leading and guiding rolls 8 to

the second applicator device 1b. After a surface treatment of the first web side W1, it may be advisable that the web W be dried at least to a certain extent prior to surface treating its second side W2. This has been illustrated with a non-contact dryer, indicated by reference numeral 9, which is for example an infradryer. In addition, fig. 1 shows deflection and guide rolls, indicated by reference numerals 4a and 5a, for deflecting a running direction of the web W as desired.

The metal belt calender 10 includes a calendering belt 12 made of metal, which circles around guide rolls 13. The calender belt 12 proceeds around a roll 15 disposed externally thereof, a calendering zone being established between the belt 12 and the roll 15. A material web W to be calendered travels through a calendering zone N, being subjected to a desired pressure impulse and heat effect as a function of time. In fig. 1, a dash-dot line 19 is shown to represent a type of pressure effect whenever inside the calendering belt 12 is disposed a nip roll 14 functioning as a press element, urging the belt against the roll 15 to establish a higher pressure nip zone within the calendering zone. On the other hand, a dash line 18 is used for depicting a type of pressure effect whenever a contact pressure acting within the calendering zone is created solely by means of a tension of the belt 12 as the nip roll 14 is disengaged from a pressing contact with the belt 12 (or when no nip roll 14 at all is installed inside the belt 12).

According to the invention, it has been discovered that the flexural strength and/or bulk of surface-sized paper/board can be improved by effecting the surface sizing with a vacuum-operated application apparatus followed by a treatment process for inhibiting or limiting a drying shrinkage, resulting in increased drying stresses. This phenomenon is based on a drying shrinkage promoting effect of starch, whereby the inhibition of drying shrinkage after the addition of starch leads to increased drying stresses. By using metal belt calendering in a treatment process downstream of surface sizing, the drying of a web can be brought about in a supported condition within a closed nip established by a metal belt and a roll, thus enabling a controlled development of drying stresses. The surfaces of a fibrous web between the hot surfaces of a metal belt calender undergo drying and moisture migrates to a middle portion, whereby the increased moisture causes swelling of the middle portions of a fibrous web and thereby increasing of bulk, which increases thickness. At the same time, the surfaces develop drying stresses, thereby increasing an elastic modulus of

the surface portions. As the fibrous web exits from the treatment zone, the vaporized water present in the middle portion escapes through the surface layers without condensing (which would cause relaxation of a high elastic modulus obtained just before), whereby the structure accomplished in metal belt calendering remains essentially unchanged and the result is an improved flexural strength of the fibrous web. This provides major savings in raw materials and improvements in quality.

Fig. 2 illustrates another way of enhancing a surface treatment. A treatment solution 30 of fig. 2 is effected by combining a film transfer coater and a metal belt calender. A surface treatment agent, e.g. a starch-based surface adhesive, is spread on top of an applicator roll 31 by means of an applicator device 32. From top of the applicator roll the surface treatment agent is delivered in a film transfer nip onto the surface of a fibrous web W. The film transfer nip is established between the applicator roll 31 and a counter-roll 34. Through the nip is further extended a metal belt 33 for effecting the coating and the metal belt calendering of a fibrous web in a single nip. A metal belt nip enables the use of high temperatures. When exiting from the nip, the fibrous web is skin dry for contact drying and, depending on running speed and temperatures, it is possible to attain sufficiently high dry contents for eliminating the needs of separate drying. This hybrid solution provides major savings in investment and operating costs and at the same enables increasing the flexural strength of a fibrous web by inhibiting drying shrinkages in the metal belt nip.

The surface treatment agent used in the foregoing solutions is preferably a CHO polymer. The CHO polymers are polymers which only contain carbon (C), hydrogen (H) or oxygen (O). Upstream of metal belt calendering, the surface of paper or board can have a CHO polymer or a CHO-polymer containing mixture applied thereto. The most familiar CHO polymers are the following:

Poly(methylene glycol)
Poly(ethylene glycol)
Poly(propylene glycol)
Poly(tetramethylene glycol)
Poly(vinyl methyl ether)
Poly(vinyl ethyl ether)
Poly(vinyl isobutyl ether)

Poly(vinyl alcohol)
Poly(vinyl methyl ketone)
Poly(vinyl ethyl ketone)
Poly(methyl isopropenyl ketone)
Poly(vinyl acetate)
Poly(vinyl propionate)
Poly(vinyl laurate)
Poly(acrylic acid)
Poly(methacrylic acid)
Poly(methyl acrylate)
Poly(ethyl acrylate)
Poly(methyl methacrylate)
Poly(ethyl methacrylate)
Poly(n-butyl methacrylate)
Poly(tert-butyl methacrylate)
Poly(lauryl methacrylate)
Poly(hydroxyethyl methacrylate)
Poly(glycidyl methacrylate)
Poly(acetylacetoxyethyl methacrylate)
Poly(glycolide)
Poly(d,l-lactide)
Poly(3-hydroxybutyrate)
Poly(ethylene adipate)
Poly(caprolactone)
Poly(pivalolactone)
Poly(ethylene-co-maleic anhydride)
Poly(styrene-co-maleic anhydride)
Poly(sebacic anhydride)
Poly(alkyl carbonate)
Poly(orthoester) based on hexamethylenediol
Poly(orthoester) based on trans-cyclohexanedimethanol
Cellulose
Ethylcellulose
Hydroxypropylcellulose
Cellulose triacetate
Poly(4-hydroxystyrene)
Poly(4-methoxystyrene)
Poly(2,6-dimethyl-1,4-phenylene oxide)
Poly(ether ether ketone)
Poly(ethylene terephthalate)
Poly(diallyl phthalate)
Poly(diallyl isophthalate)
Poly(bisphenol A carbonate)
Carboxymethyl cellulose (CMC)

The application of polymer can be effected e.g. by nozzles, but other application methods are also possible. In a metal belt calender, the paper or board web dries effectively, so a separate dryer is not absolutely necessary. As the case may be, the paper or board web can also be dried prior to metal belt calendering. The process is

particularly preferred for the finishing process of uncoated grades. The uncoated grades can be subjected to separate calendering subsequent to metal belt calendering. For coated grades, the process is preferably suitable for use as a pretreatment prior to coating. A polymer treatment and metal belt calendering can also be effected after coating or between coating units. A metal belt calender can also be positioned in the drying section.

The surface of printing paper can be treated with tailored chemicals, such that an improvement of the printing surface is achieved by using a very small amount (<0.5 g/m^2) of chemical. Such a chemical is e.g. a polymer, the hydrophobic properties of which are strongly dependent on how the polymer molecule settles on the surface. By opening polymer molecular micelles (or molecular clusters) on the surface of paper fibers, the hydrophobic groups of molecules will be directed away from the surface. Thus, the opening of molecular micelles can be used for maximizing the hydrophobic effect (or the effect on a resulting print quality). The opening of micelles onto the surface of fibers can be assisted by a heat treatment subsequent to the chemical application, e.g. by a treatment in a long-dwell (tens of milliseconds or longer) calendering belt zone. In particular, the process can be implemented with a metal belt calender. Alternatively, the treatment may comprise various thermal treatments used in drying, such as hot-air blasting. However, concurrent calendering and heat treatment provide benefits, since printing paper must be calendered anyway after the chemical treatment and, hence, the micelle treatment can be integrated with calendering

The chemical can be applied by any prior known application method, such as spray, film transfer, blade or curtain coating. In the case of multiple curtain coating, it is preferably the top layer of coating that contains said polymer.

Consequently, the final sequence of chemical preparation can be envisioned to occur on the surface of paper as the structure of polymer molecules is conditioned for a desired final result by a thermal treatment effected on the surface of paper. This solution offers considerable benefits:

- A demand for chemical treatment can be minimized and still achieve significant benefits, the effect of chemical being maximized as the hydrophobic effect of polymers is enhanced by thermal treatment.

- Coating, chemical treatment, and calendering processes can be integrated further.

Claims

1. A method for the surface treatment of paper/board, **characterized** in that the method comprises treating a fibrous web with a drying-shrinkage achieving chemical, such that the chemical penetrates substantially throughout the fibrous web thickness, and thereafter the fibrous web is set to proceed to a treatment zone (N) between two heated metal surfaces (12, 15) with a result that moisture within the fibrous web migrates into a middle portion, whereby the middle portion swells as a result of increased moisture and the surface portion is subjected to a high drying stress as the surface portion is prevented from shrinking, and as the fibrous web exits from the treatment zone, the vaporized water escapes rapidly through surface pores without substantial condensation in the surface layers, resulting in an increased elastic modulus for the surfaces and at the same time a low density for the middle portion.

2. A method as set forth in claim 1, **characterized** in that the method comprises the use of a metal-belt equipped treatment unit (10) which establishes said treatment zone between the heated metal surfaces (12, 13).

3. A method as set forth in claim 1 or 2, **characterized** in that the treatment chemical comprises starch.

4. An apparatus for the surface treatment of paper/board, **characterized** in that the apparatus comprises an application unit (1), by means of which a drying-shrinkage achieving chemical is applicable to a fibrous web, such that the chemical penetrates substantially throughout the fibrous web thickness, and the fibrous web is adapted to proceed through a treatment zone (N) between two heated metal surfaces (12, 15) with a result that moisture within the fibrous web migrates into a middle portion, whereby the middle portion swells as a result of increased moisture and the surface portion is subjected to a high drying stress as the surface portion is prevented from shrinking, whereby, as the fibrous web exits from the treatment zone, the vaporized water escapes rapidly through surface pores without substantial condensation in the surface layers, resulting in an increased elastic modulus for the surfaces and at the same time a low density for the middle portion.

5. An apparatus as set forth in claim 4, **characterized** in that the apparatus comprises a treatment unit (10) which includes said treatment zone (N) between the heated metal surfaces (12, 15).

6. An apparatus as set forth in claim 4 or 5, **characterized** in that the application unit (1) comprises chemical applicator means (1a, 1b) disposed on one side of a fibrous web for applying a chemical to a surface (W_1,W_2) of the treated fibrous web, and a vacuum device (3a, 3b) disposed on the other side of the fibrous web, which is used for establishing a pressure difference throughout the thickness of a fibrous web (W), resulting in a migration of the chemical from the side facing the applicator means towards the opposite side.

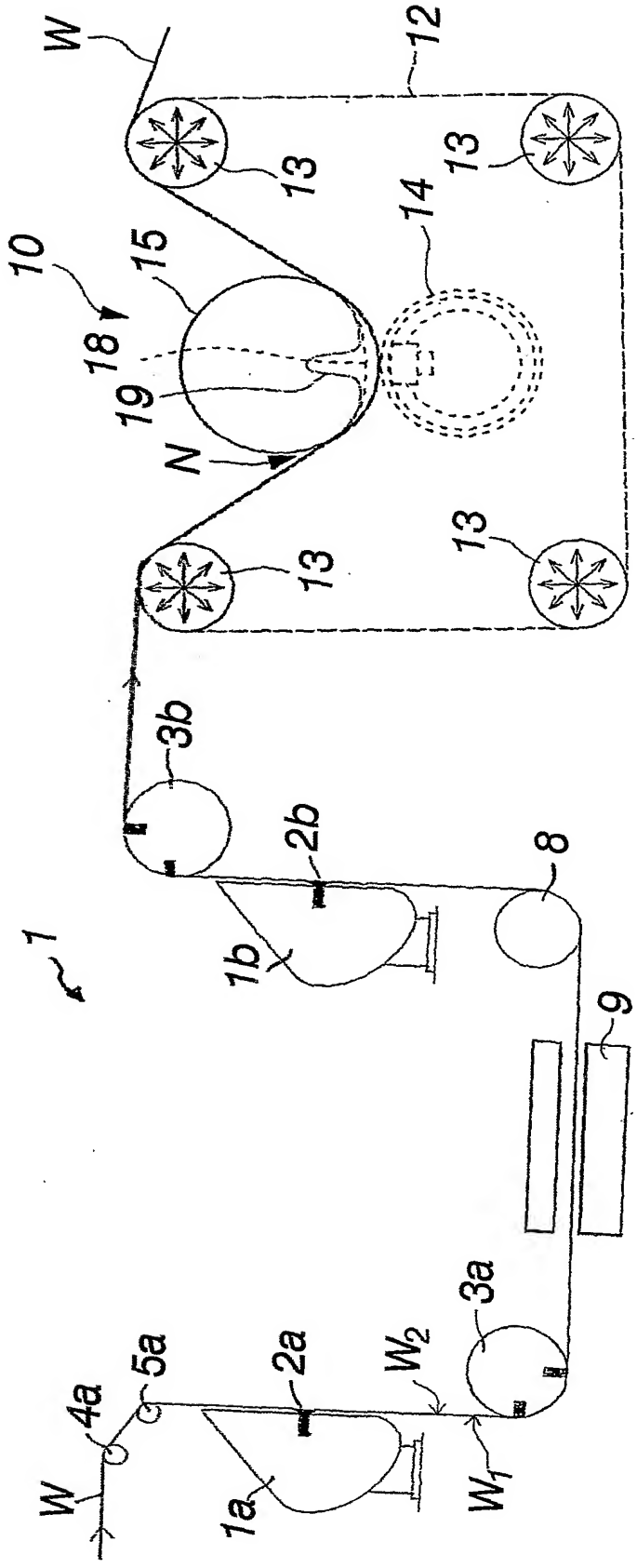

Fig. 1

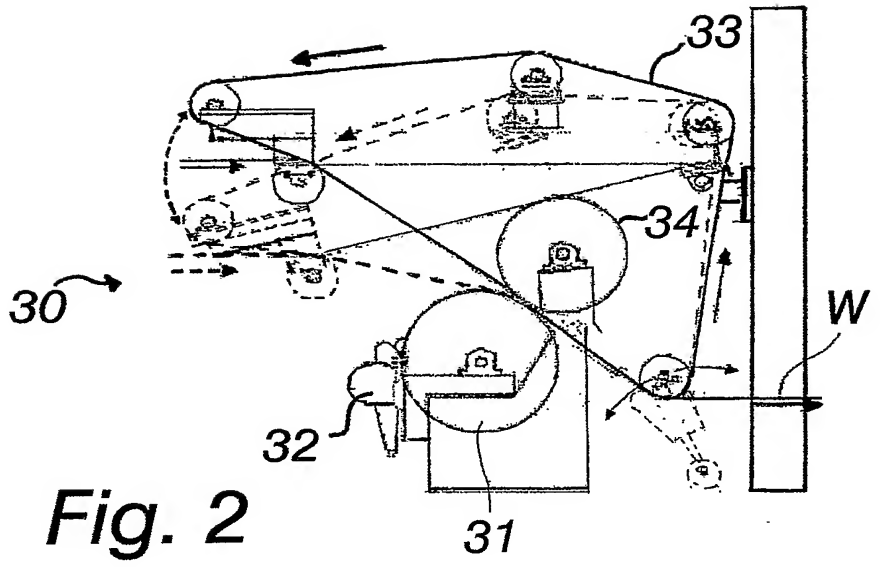

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2007/050202

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: D21H, D21F, D21G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 102004048430 A1 (VOITH PAPER PATENT GMBH), 13 April 2006 (13.04.2006), page 2, paragraph 0010; page 3 paragraph 0012,0018-0025; page 5, paragraph 0044,0055-0057; page 6, paragraph 0062, figure 5,8, claims 1,11,12, abstract	1-5
Y		6
	--	
X	WO 0225013 A1 (EKA CHEMICALS AB), 28 March 2002 (28.03.2002), page 1, line 9 - line 11; page 1, line 29 - line 34; page 9, line 32 - page 10, line 1, claims 1-2,4, abstract	1-5
Y		6
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2007	03-09-2007
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Monika Bohlin/CM Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2007/050202

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03064764 A1 (METSO PAPER INC), 7 August 2003 (07.08.2003), page 22, line 28 - page 23, line 17, figure 1, claims 82-88, abstract	1-5
Y	--	6
Y	WO 2004109015 A2 (METSO PAPER INC), 16 December 2004 (16.12.2004), figure 1, claim 1, abstract	6
	--	
A	WO 2006024695 A1 (METSO PAPER INC), 9 March 2006 (09.03.2006), paragraph 0106, figure 2, claim 13, abstract	1-6
	--	
P,X	WO 2006058963 A1 (METSO PAPER INC), 8 June 2006 (08.06.2006), claims 1-5, abstract	1-6
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2007/050202

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 1 in part and 4 in part
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

See separate page

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

Cont of Box II

Present claims 1 and 4 relate to a compound defined by reference to a desirable characteristic or property, namely a drying-shrinkage achieving chemical. The claims cover all compounds having this characteristic or property, whereas the application provides support within the meaning of Article 6 PCT and / or disclosure within the meaning of Article 5 PCT for only a very limited number of such compounds. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Independent of the above reasoning, the claims also lack clarity (Article 6 PCT). An attempt is made to define the compound by reference to a result to be achieved. Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible.

Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to the compounds mentioned in the description on page 1 lines 12-20 and page 12 line 31 to page 13 line 44.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2007/050202

International patent classification (IPC)
D21H 25/06 (2006.01)
D21H 21/14 (2006.01)
D21H 23/24 (2006.01)
D21F 5/00 (2006.01)

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Use the application number as username.
The password is **QYDLDLCZVN**.

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

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WO	2006024695	A1	09/03/2006	EP	1784535	A	16/05/2007
				FI	20045321	A	03/03/2006
WO	2006058963	A1	08/06/2006	CA	2584662	A	08/06/2006
				FI	20045464	A	31/05/2006

PUB-NO: WO2007128867A1

DOCUMENT-IDENTIFIER: WO 2007128867 A1

TITLE: METHOD AND APPARATUS FOR THE SURFACE TREATMENT OF PAPER/BOARD

PUBN-DATE: November 15, 2007

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APPL-NO: FI2007050202
APPL-DATE: April 18, 2007

PRIORITY-DATA: FI20065306A (May 9, 2006)

ABSTRACT:

CHG DATE=20071116 STATUS=O>The invention relates to a method and apparatus for the surface treatment of paper/board. The method comprises treating a fibrous web with a drying- shrinkage achieving chemical, such that the chemical penetrates substantially throughout the fibrous web thickness, and thereafter the fibrous web is set to proceed to a treatment zone (N) between two heated metal surfaces (12, 15) with a result that moisture within the fibrous web migrates into a middle portion, whereby the middle portion swells as a result of increased moisture and the surface portion is

subjected to a high drying stress as the surface portion is prevented from shrinking. As the fibrous web exits from the treatment zone, the vaporized water escapes rapidly through surface pores without substantial condensation in the surface layers, resulting in an increased elastic modulus for the surfaces and at the same time a low density for the middle portion.